THE EXACT MEASUREMENT
OF THE ELECTRIC CURRENT, AND OTHER
PRACTICAL POINTS IN

The Destruction of Hair by Electrolysis,

WITH ESPECIAL REFERENCE TO THE USE OF THE
ABSOLUTE GALVANOMETER.

BY

MORTON PRINCE, M.D.,

Physician for Nervous Diseases to Out-Patients, Boston City Hospital.

[*Reprinted from the Boston Medical and Surgical Journal of November 4, 1886.*]

BOSTON:
CUPPLES, UPHAM & CO., PUBLISHERS,
Old Corner Book Store.
1886.

ON THE EXACT MEASUREMENT OF THE ELECTRIC-CURRENT AND OTHER PRACTICAL POINTS IN THE DESTRUCTION OF HAIR BY ELECTROLYSIS, WITH ESPECIAL REFERENCE TO THE USE OF THE ABSOLUTE GALVANOMETER.

BY MORTON PRINCE, M.D.,
Physician for Nervous Diseases to Out-Patients, Boston City Hospital.

To remove hair by electrolysis is a very easy operation, but it is not so easy to do it without leaving behind disfigurements, either temporary or permanent. One of the disadvantages connected with the process is the dermatitis which is apt to follow the operation, to say nothing of the more severe papular inflammations, and not infrequent ulceration of the hair-follicles. Worse still, because permanent, are the scars. The latter, to be sure, even on a woman's face, are a small disfigurement, excepting when the process has been badly done, compared to that caused by unsightly hairs; still, they are scars. The dermatitis, to be sure, is only temporary, lasting only a few days, but while it lasts the skin is sore, and the face decidedly disfigured. The small ulcerations of the hair-follicles, small as they are, are of more importance, as they lead to comparatively large scars, instead of the almost invisible cicatrices left, if any at all develop, by the process when properly done. It should be stated, however, that even minute cicatrices are not a necessary result.

It is generally stated by those having experience with the operation, that these ill effects are dependent upon the peculiarities of the individual skin, some skins bearing the operation without any bad after-effects, while others are easily inflamed. While there is considerable truth in this, and there is even a difference

in the capacity of different parts of the skin of the same face to bear electrical currents without inflammatory reaction, still I have long suspected that the greater part of the difficulty is due to the intentional or unintentional use of excessively strong currents, and that such unintentional use is due partly to the fact that no proper means are employed to measure the strength of the current, and partly to the fact that a current from a given number of cells varies immensely in strength during the course of a single sitting, owing to the varying resistance offered by the skin. To overcome the undesirable effects which are consequences of these difficulties, I have hitherto advocated using the weakest currents possible, preferring to have more hairs come back to be operated upon again, rather than run the risks of pustules and disfiguring scars. Though secondary inflammation and cicatrices have in this way been mostly avoided, still the operation has been beset with great annoyances, such as the sudden weakening of the current below the strength practically necessary for the destruction of the hair papilla, with consequent imperfect results, necessitating tedious fussing with the battery, while again, the strength of the current may suddenly rise, for various reasons, above the required point, etc., etc. It was not till I began using the *absolute* galvanometer that I found a practical method of gauging the strength of the current, nor till then did I appreciate the extent of the fluctuations that may occur in the current strength in the course of a single sitting. Nothing is more uncertain and useless than the methods usually recommended by those who practise the operation for determining the strength of the current. Every writer on the operation, that I have seen, directs either that so many cells be used, or that a current sufficient to produce effervescence at the needle be employed.

Now, for reasons that will be presently explained, a most powerful current — one sufficient to produce severe destruction of tissue — may be unwittingly used without effervescence occurring, and in the second place, with the same number of cells, the current may vary five-fold, at least. It has been long known to electro-therapeutists that the number of cells, even aside from the difference in strength of the cells of different forms of batteries, is no guide whatever to the strength of the current. Another factor, besides the electro-motive force of the cells, must be taken into consideration, namely, the resistance to be overcome. This varies immensely, according to the size and construction of the electrodes, the degree of pressure with which they are applied to the body, the condition of the skin, its dryness or moistness, the portion of the body to which the electrode is applied, etc., etc. That these are no theoretical difficulties, but practical ones, may be seen by the results obtained in the following experiment: A current from the same number of cells was applied through the same electrodes, thoroughly wet at each application. The resistance of the skin over the spine had previously been reduced to a minimum by prolonged applications.

1. One electrode over palm, other over back of hand.	Current =	2	Milliampères.
2. One over spine, other over palm.	"	2	"
3. One over spine, other over back of hand.	"	6	"
4. One over each lateral half of back.	"	8	"
5. One over spine, other over forearm (front)	"	9	"
6. One over front, other over back of forearm	"	9	"
7. One over spine, other over back of forearm	"	10	"
8. Both ever spine.	"	10	"
9. One behind each trochanter.	"	11	"

Or, in other words, with the same given number of cells and the same electrodes, the current may be increased from two to five times, according to the different location of the electrodes in the same individual.

Again, with the positive electrode over the back or front of the forearm, negative on some part of the face, the current frequently varies, in the experience of the writer, between one and three milliampères, though the same number of cells be used, according as the needle is inserted in different parts of the same face.

The same thing happens, as would naturally be expected, with a current from the same number of cells applied to different persons, though the conditions be made as far as possible alike. I have found that after taking all possible precautions to apply the poles to the same regions, and after reducing the resistance of the skin to the minimum, that from twice to three times as strong a current may pass through one person as through another, though the same number of cells be used. Again, the fluctuations in the current strength dependent upon the size of electrodes may be seen from the following experiment:

The same number of cells were used in each case, and the electrodes applied to the same region of the body, namely, the thighs. The electrodes were of five sizes, No. 1 being the smallest, and about the size of the top of a slate pencil. The largest, No. 5, measured 3 × 6 inches, but the whole surface was not in complete contrast.

With electrodes	No. 2	and	No. 1, current	= 3	Milliampères.
"	No. 2	"	No. 3, "	= 6	"
"	No. 2	"	No. 4, "	= 7	"
"	No. 2	"	No. 5, "	= 9	"
"	No. 5	"	No. 5, "	= 14	"
"	No. 5	"	No. 1, "	= 6	"

To show how useless is effervescence as a guide, the following experience (of frequent occurrence) jotted down at the time, will show. The writer was removing from the neck some fine hairs, which grew at a very acute angle with the skin, and, therefore, somewhat difficult to destroy. After applying the current for the usual length of time, the hairs were found to

be still firmly attached and no effervescence had occurred. The natural impulse would have been to increase the current, but a glance at the galvanometer showed that a current of three milliampères was passing — three times as strong as was necessary. The fault lay in an inaccurate direction given to the needle, and the inability of the gases to escape to cause effervescence.

Furthermore, effervescence is not necessary for the destruction of the hair bulb. Hairs can be destroyed, as I have repeatedly demonstrated, without the slightest appearance of effervescence.

The variations in the current-strength caused, even, by different modes of applying the electrodes to the skin may be seen from the following:

Twelve cells were used. A large electrode, $3\frac{1}{4} \times 6\frac{1}{4}$ inches, was applied to the forearm, while a small electrode, $1\frac{1}{2}$ inches in diameter was successively applied, first, to the centre of palm of hand so that only one surface was in contact with skin; second, between the thumb and palm so as to be held by pressure of the thumb; and third, to the centre of palm but grasped by the fingers. In this way the amount of surface in contact was successively increased. The strength of current obtained was as follows:

1st Method	$\frac{1}{2}$ Milliamp.
2d "	$\frac{3}{4}$ "
3d "	1 "

The following experiment was undertaken to show the variations in current-strength due to variations in size of the positive electrode in conjunction with a needle inserted into a hair follicle for electrolytic purposes.

1. Small electrode. ($1\frac{1}{2}$ inch) to palm	$\frac{1}{2}$ Milliamp.
2. " " " grasped	$\frac{3}{4}$ "
3. " " " to forearm	$1\frac{1}{2}$ "
4. Large electrodes, ($3\frac{1}{4} \times 6\frac{1}{4}$ in.) to palm	$1\frac{1}{2}$ "
5. " " " " to forearm . .	2 "

In other words, the large electrode applied to palm gave six times as strong a current as the small electrode, etc.

One more experiment shows the different results obtained by electrodes of different sizes, construction and conditions of moisture used in conjunction with the electrolytic needle.

Electrode covered with cotton. 1 in. diam.		Electrode covered with sponge. 2 in. diam.	
1. To palm	½ Milliamp.		1 Milliamp.
2. To forearm	1 "	2-3	"
3. To palm	sponge allowed to become comparatively dry.	½	"

Here it will be seen that the current obtained with a sponge electrode, after the water had been squeezed out, as always happens after a few minutes use, was reduced one-half.

It should be stated that the smaller electrode was a polished copper disc covered with absorbent cotton, one of the best conductors. While the large one was covered with chamois-skin, and its metallic surface, as I afterwards discovered, was corroded and covered with verdigris, consequently its conducting power must have been greatly impaired. I suspect that if it had been constructed like the smaller one the differences would have been still more marked. It should be mentioned that the resistance of the skin in these experiments was reduced to a minimum by the usual methods.

A variation in the strength of the current may even be produced by the needle not being inserted to the same depth in the skin. I have seen the current doubled from this cause.

Under these conditions, then, it cannot be wondered at that the effects of electrolysis are uncertain, sometimes resulting in dermatitis and scars, and sometimes in destruction of the hair alone, without the slightest disfigurement. It must be apparent to any

one that, to get the best results from electrolysis, we must have some accurate method of measuring and regulating the strength of the current. This can be done by means of the *absolute* galvanometer, which, I have found, answers every purpose, and which I now always use. By its means the current can be accurately and easily regulated, and any fluctuation in its strength immediately detected. Discovering the fluctuation, it is easy to determine the cause, and to guard against its reoccurrence. The practical results obtained I have found to be far better than formerly. Pustules can be wholly and cicatrices almost entirely, even if not absolutely, avoided. When one has once used such an instrument, providing he has a reliable one, he will be loth to give it up. No small advantage is that one learns the conditions essential for a steady current, and is thus able to prevent variations. An increase of one milliampère in ordinary electrotherapeutics is of no consequence, but in such delicate operations as electrolysis, it is of the greatest consequence. A case in point will illustrate these advantages.

It is that of a young girl who had a very abundant growth of hair upon her face, necessitating repeated operations, extending on and off over a space of two years. It so happened that the skin under her jaw was very sensitive to electricity, so that electrolysis was always followed there by more or less inflammation and scars, be as careful as I would. In contrast, to this, on the sides of her face, she could bear comparatively strong and repeated currents with immunity. Under the jaw, on the other hand, only very few hairs could be done at a sitting, and that with very mild currents. Pustules, dermatitis and fine scars were frequent effects. Since using the absolute galvanometer all this has changed. I can now do what remains to be done without any secondary inflammation, and so far as I can see without any scars what-

ever. And I believe it to be *theoretically* possible to always remove hairs without scars. Practically it is difficult because the requisites are absolute care and great physical endurance on the part of the operator. The endeavor should be to direct the action of the current, as far as possible, to the hair bulb and follicle alone. This can only be approximated by accurately inserting the needle and using the weakest currents for the shortest period compatible with effective practical results.

But supposing an absolute galvanometer is to be employed, what rules should be observed in performing the operation; what strength of current should be employed, and for what length of time? The directions laid down by most writers are most indefinite, and do not show an intimate knowledge of either theoretical or applied principles of electricity. A late English writer, whose article lies before me and whom I quote merely to bring out the points I wish to enforce, gives the following directions: a battery of from ten to fifteen cells is to be used; the current is to pass from ten to thirty seconds until slight frothing is produced or a wheal appears around the mouth of the follicle. It is also stated that it is not absolutely necessary that the needle should be inserted directly into the follicle, as the requisite destruction occurs if the instrument be in its immediate neighborhood, and that papules and pustules result, which remain visible for some weeks.

That papules and pustules result under these circumstances can scarcely be wondered at. There can scarcely be any better way of producing them, as well as scars, than some such method as this.

The danger of relying upon the number of cells to determine the strength of the current has already been shown. Ten to thirty seconds is altogether too long for any current generated by ten to

fifteen cells of a good working battery, unless a great resistance is offered by the circuit, which cannot be known without an absolute galvanometer; and, according to the experience of the writer, a wheal should never be produced. Any current which produces a wheal, especially one that is white and sharply circumscribed, is too strong. Furthermore, I believe it to be absolutely essential that the needle should be inserted directly into the follicle and through the papilla, but not beyond if possible, if cicatrices are to be avoided.

The writer has made numerous experiments to determine what strength and duration of current gives the best results. Before stating the specific conclusions arrived at, the following general principles may be laid down. The weakest possible current of the shortest possible duration compatible with efficiency in the time at the operator's disposal should be used. If there is much work to be done, less time can be given to each individual hair. But the stronger the current and the longer its duration, the greater certainty of after inflammation and scars. On the other hand, with very weak currents, say under one-half milliampère, the time requisite to destroy the hair-bulb is too long for practical purposes, especially if there is much to be done; for the stronger the current the shorter the time needed, and *vice versa*. As a matter of experience, and as the result of numerous observations, I have found that a current of one milliampère, passing from two to three seconds, is the best. It should be not less than one-half nor more than two milliampères. With one-half milliampère it can be easily done, but takes longer. Such a current is, perhaps, to be preferred if only a few hairs are to be destroyed. With more than two milliampères pustules and scars are almost sure to result. It must be understood that the stronger the current, the shorter

time must it be allowed to pass, and the greater the pain.

My plan is always to watch the needle of the galvanometer, and if it swings towards two milliampères, to shorten the duration, and if it goes beyond two milliampères to immediately break the current. I do not mean to say that it is impossible to use stronger currents without causing bad after-effects, but it is very difficult to do so, and the current must be broken almost immediately after being made. With a current of one milliampère, three seconds is amply long enough for the current to flow. This I have repeatedly determined with watch in hand. If the hair be not destroyed in that time, the reason therefor will almost always be found to be that the needle has not been accurately introduced within the hair follicle so as to hit the bulb.

Of course the stronger the current and the longer it be allowed to act the easier it is for the operator to successfully work, and hence there is always an inducement to use strong currents. If a current of one milliampère acting for three seconds will decompose the tissue within a radius of, say, 1-50 inch, for example, a current of three milliampères will decompose all the tissue within 3-50 inch, or thereabouts; and therefore with the latter current much less care need be employed in introducing the needle, as it has only to be placed somewhere near the hair, and all the neighboring tissue must succumb, hair and all, hence cicatrices.

For this reason the needle should be accurately inserted into the follicle and papilla. If it is placed simply in the neighborhood of the latter, all the intervening tissue must necessarily be exposed to the electrolytic action. Greater destruction of tissue than necessary will then be occasioned, and pustules and scars must result.

Sponge electrodes are very undesirable, as their conducting power rapidly changes as the water becomes squeezed out.

There is one more practical point which should be mentioned. The patient should never be allowed to hold the positive electrode in the hand, as is usually advised. What between the great resistance offered by the palm of the hand involving the necessity of keeping the thick dry skin thoroughly soaked with water, and the unevenness with which a patient presses with the electrode, it is impossible to maintain anything like a steady current. If the current hurts, the patient is sure to let up on the electrode. Under such conditions I have sometimes found it impossible to do the operation at all, the galvanometer at times marking no current and then again jumping to three and four milliampères. A large electrode, covered either with chamois-skin or a thin layer of absorbent cotton, not sponge, should be fastened to the forearm, as the most convenient place. It is hardly necessary to refer to the danger of using the positive instead of the negative pole in connection with the needle or destroying at one sitting hairs situated close together, as these points have been referred to by other writers.

The powerful electrolytic action of electricity on tissue, and the possible disastrous effects of strong and long continued currents may be seen from the following experiments, out of a number of others made by Dr. T. D. Davis,[1] some time ago, in connection with another operation. The first experiment was made with a 30 cell Grenet battery, the second with a 15 cell Bunsen battery.

(1) Two steel needles, thickness of knitting needles, were introduced into the tissue of a healthy liver within half an inch of each other. Immediately afterwards bubbles of gas commenced to issue from the cut surface of the liver, which was

[1] Philadelphia Med. Times, October 2, 1871.

nearer to the points of the needles than the place of their introduction. In four minutes the needle connected with the negative pole became very loose, and bubbles of gas escaped around its point of entrance. In five minutes the needles were withdrawn, the negative one coming away easily, while the positive one, which was blackened and roughened, was firmly adherent. On cutting across the track of the negative needle, a cavity, one quarter by an eighth of an inch in diameter, was discovered, surrounded by a darkened gelatinous tissue, one-eighth of an inch in thickness. Extending from this to the point where most of the gas escaped was a mass resembling that surrounding the cavity, looking more like softened glue than healthy tissue. The track of the positive pole was black and charred, but the tissue immediately surrounding the point was firmer and whiter than in other parts.

(2) A cat was put under the influence of chloroform and the needles were introduced into the right thigh one inch apart. Soon the fizzing sound was heard, which continued until the needles were withdrawn, at the end of ten minutes. The tissue was softened around the negative and much hardened around the positive needle. The needles were then introduced into the left thigh of the same animal, and retained there for ten minutes. In the post-mortem examination, several days later, the skin on the right thigh was found ulcerated for an inch in diameter. The muscles were separated down to the heel but not to the bone. There was a cavity under the skin large enough to hold a walnut. The left thigh presented similar appearances. the cavity being as large as an egg, and the muscles separated down to the bone, as well as softened and eaten away. Part of the femur was denuded of periosteum, but not eroded.

These, of course, are the effects of powerful currents long continued, but the action from weak currents is the same in kind, differing only in degree, and these experiments show how it is possible to produce on the face irreparable injury unless care be used.